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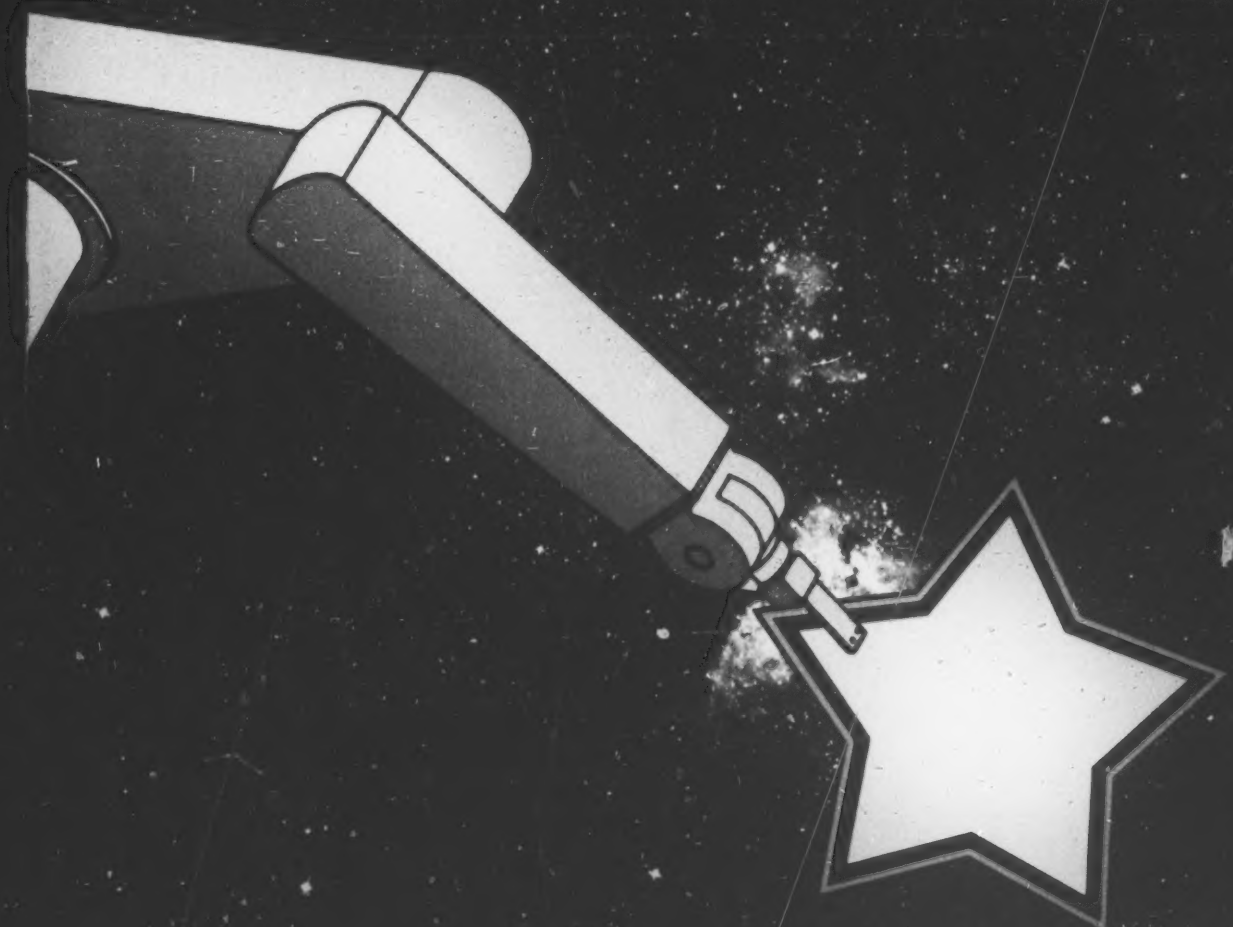
MANUFACTURING MANAGEMENT



ASSEMBLY ROBOTS: THE FASTEST RISING STAR IN A HOT TECHNOLOGY

TODAY'S MANAGER—PART THREE IN A SERIES: HOW NEW JOBS ARE FOUND; NEW CAREERS LAUNCHED

TOMORROW'S SURFACE COATINGS: THEY'RE HERE TODAY

JUNE 21, 1985 VOL. 228, NO. 12

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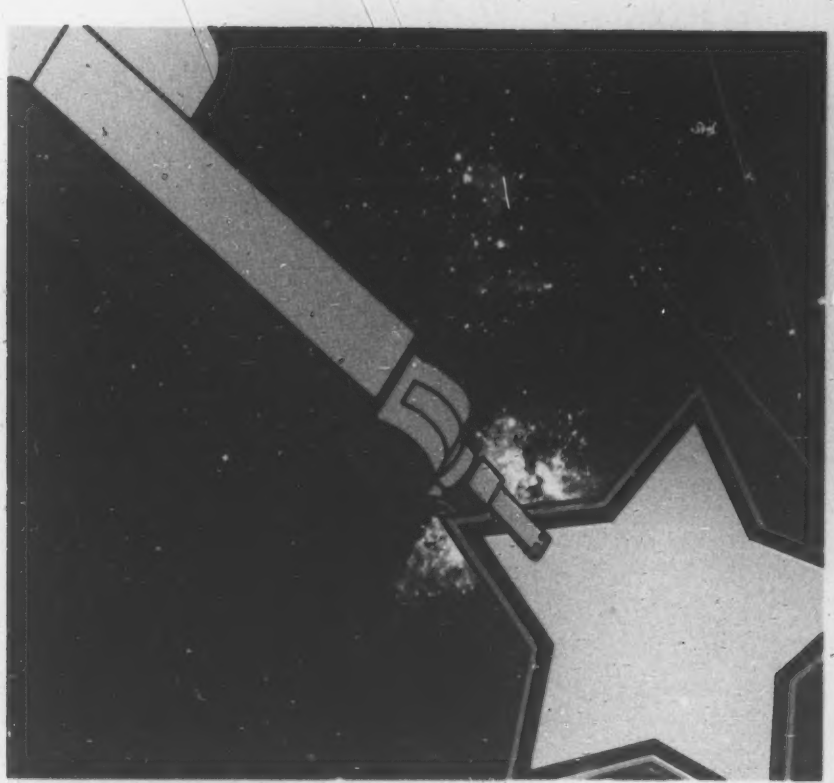
MANUFACTURING MANAGEMENT



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THE FASTEST RISING STAR IN A HOT TECHNOLOGY

For years the great promise of robotics was to reach fulfillment in assembly operations. But only now are the manufacturers beginning to open their assembly room doors to robots.

BY ROBERT E. HARVEY

It used to be that robots and assembly were as compatible as oil and water. Firms bought robots that sprayed paint, spot welded, and moved materials about, but were, by and large, unable to integrate the promise of the robot with the needs of flexible assembly. Assembly robots were considered misfits. They were not as adaptable nor as easily taught as human assemblers; nor were they as fast or as accurate as fixed automation systems.

However, times have changed. In recent months, demand for assembly robots—particularly by automotive and electronics firms—has been strong. Purchases of assembly robots in the U.S. in 1984 were double 1983's totals. The figures will almost double again in 1985.

Nor will the growth stop here. A division of A.C. Nielsen Co., Dataquest Inc., a research facility in San Jose, Calif., predicts that purchases of robots by firms in the U.S. will grow at a compounded annual rate of 74 pct through 1988. Others are almost as optimistic. "Over the next couple years you may see the use of assembly robots grow at 50 pct or more per year," suggested Richard H. Johnson, Manager of Product and Market Planning, GMF Robotics Corp., Troy, Mich.

This sudden popularity is due, in no small degree, to a spate of technological developments, but the primary driving force is the growing awareness of the value of robotic assembly. This awareness, however, has been slow in dawning. Therefore, the Japanese have a sizable lead over the U.S. in applying robots to assembly operations.

But that lead is being shortened by U.S. manufacturers who no longer perceive assembly robots as misfits but as devices that combine the best of humans and fixed automation. Robots, unlike people, do not get tired or produce parts of inconsistent quality. Nor are they hamstrung by the inflexibility inherent in other automation systems.

Increased foreign competition, the need to reduce inventories, and the imperative to improve quality is pushing increasing numbers of U.S. firms into robotic assembly.

The growing cost of carrying inventory and the increasingly volatile marketplace is forcing firms to examine flexible small batch assembly methods. The smaller the batch and the more flexible the operation, the faster a manufacturer can respond to changing market conditions and the less inventory he is stuck holding.

Robot Lines Can Be Flexible

Programmable robots give companies the ability to quickly restructure assembly lines as well as manufacture multiple products over a single flexible automated line. A manufacturer can greatly reduce costs if he is able to run several assemblies over the same line, taking advantage of the built-in flexibility of robots.

Even companies that don't need flexibility are buying robots. They are buying them off the shelf and adapting them to dedicated assembly rather than spending months and many dollars building specialized assembly equipment.

Not everyone is buying the same kinds of assembly robots, however.

Robots specifically designed for assembly, like this robotic system from IBM, combine the high flexibility of humans with the speed of automation.

"People in the robotic community are in agreement that there is a two-phased marketplace," said Mr. Johnson. "At one end, the market is demanding robots with higher function capability, while firms at the other end of the spectrum are looking for robots with lower level functions. The interest in the low level assembly robot is being sparked by the customer wanting to redesign his product line for robotic assembly."

There is no question that the Japanese lead the world in incorporating simple, fast, accurate robots into their operations. Japan has been at this game a little longer than the U.S., so they have many more robots installed in assembly.

The Japanese are very good at redesigning products so that they can be assembled by these limited capacity robots, robots with arm movements in only three or four axes. More general purpose robots usually

move through six axes.

The principal type of simple robot used by the Japanese is the SCARA (selective compliance assembly robot arm) robot. However, cylindrical and Cartesian-type robots are also common.

"Robotic assembly is just in its infancy in the U.S.," explained Glen Rohn, sales and marketing manager, VSI Automation, Troy, Mich. "One reason for its recent growth has been the introduction into the American marketplace of robots like the SCARA that have been particularly designed for assembly." In the past, robots were designed to be universal manipulators; however, today's robots increasingly are being designed for specific operations.

Robots, like the SCARA type, are very well suited for particular types of automated assembly. For years, the Japanese have been redesigning assembly to take advantage of the the strengths of these robots. Because these robots have only limited axes of movement, products are often assembled on a plane; and most items are assembled perpendicular to that plane.

Part Location Replaces Vision

"These robots don't need vision," remarked Mr. Johnson of GMF, "because they can accurately locate parts and put them wherever needed. Even if the part is a little out of location, the robot will self-locate the part if the design changes that enable a robot to self-locate are put in place."

According to Mr. Rohn, with his firm's SCARA robots the "hold" on a robot arm can be relaxed allowing it to float free. With the proper fixturing, this floating arm can be guided into position to use a screwdriver or insert a fastener, even when the robot positioning or the part alignment is not perfect.

Opposite the low-end limited-function robots are the more sophisticated robot. Robots with advanced tooling; robots that can see, feel, and smell; robots that can adapt to unexpected changes in the workplace. In addition, these robots are being linked into networks to provide even greater flexibility and faster response. For example, based on simple commands from a high level network, a robot system can effortlessly change from assembling four-door cars to a two-door cars.

As robots grow in sophistication they become able to perform an increasingly wide range of assembly tasks. These sophisticated robots have so far made their appearance in small numbers but reportedly they are the wave of the future. Many experts believe that in five years nearly all robots sold will be able to see what they are doing.

"Robots are getting more sophisticated, which is making them applicable to more assembly tasks," said Mr. Johnson, "and that is what I would call the upper end or the sophisticated robot. As far as the vision interface, there are many viable vision systems both for two-dimensional finding and three-dimensional finding."

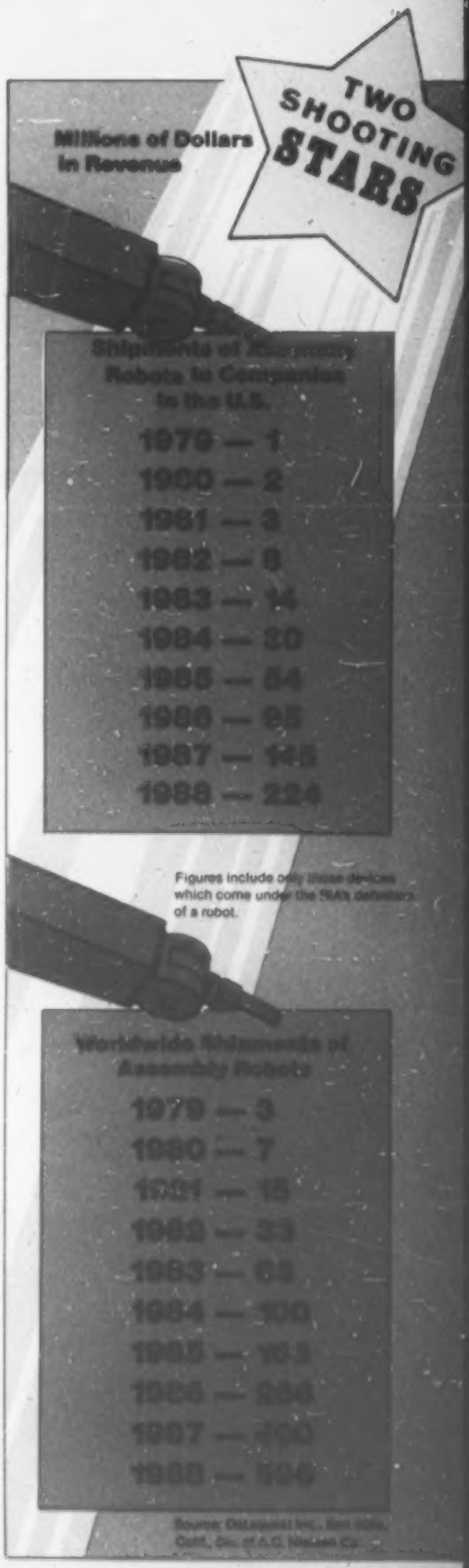
Waiting For The Perfect Robot

Some manufacturers, who do not yet use robots for assembly, are waiting for these advanced robot systems to be perfected. Vision and tactile feedback systems, they remark, are presently too expensive and too slow for many applications.

Industry experts counter this by pointing out that better robots will always be just around the corner; the robots available today are efficient, proven devices. And, they say, people who are not seriously looking at using robots for assembly are simply procrastinating.

"Because of the intensity of labor in assembly, there is little question about the need for robots in assembly," explained Vernon E. Estes, manager of product planning and market development of General Electric's Robots and Vision Systems Dept., Orlando, Fla. "A lack of technology is not the reason for a lack of robots in assembly. The problem has been to get enough managers educated to understand that there are benefits, achievable benefits, to be realized.

"I don't think that new technology is the chief driving force for robot usage because much of the technology is not particularly new. It is just that we have needed an understanding of the benefits and the people



Robotic assembly, the middle ground between manual and fixed automated assembly, attempts to combine the best of both worlds.

Manual Assembly
- very flexible
- easily taught
- very adaptable to change
- requires little tooling
- automatically inspects work
- costs constantly increase
- gets fatigued
- variable quality
- variable speeds

Robotic Assembly
- ideally, the best of both worlds

Fixed Assembly Automation
- very repeatable
- very reliable
- very fast
- limited flexibility
- expensive
- not adaptable
- untiring

with the ability to implement them. We have a lot more technology than implementation talent right now."

Sitting around, just waiting for the super, high-tech robot to come along is not the direction most companies should go, asserts Mr. Estes. "In most cases we have seen that the sophisticated vision-enhanced, all-everything robot was not what was needed. What was needed was just speed and accuracy. And even accuracy often can be compensated for. Mechanical compliant devices are available that allow for inaccurate positioning. Most electronic sensing and other sophisticated equipment has slowed operations down. You can't afford that."

In the near term, then, the growth of robots for assembly will depend on improved methods to deliver oriented parts to the robot's work area, rather than on vision and tactile feedback systems which tend to be too expensive and too slow for many applications.

Vision, Tactile Sensing Used

While it might not be best strategy for the average manufacturer to plunge right into top-of-the-line robotic assembly systems, applications do exist where very advanced robots using tactile sensing, vision, adaptive control, and other advanced technologies perform very well.

Tom Reynolds, director of product marketing for Automatix Inc., Burlington, Mass., insists that for certain applications, vision and tactile sensing is a viable alternative to older assembly techniques. "This technology is clearly right today to solve some problems. Many of the problems that can be solved by vision are those not being automated today. It just has been too costly to do so—probably because tooling and fixturing costs are prohibitive. For example, tire loading on an automobile is impractical to do with hard tooling, but is a problem that can be solved today through the use of vision and robots."

Most robotic vision systems are operating in electronics or automotive companies. The reason is that they are under tremendous pressure from the competition to automate. In addition, both industries feel comfortable implementing innovative automation.

Assembly robots with vision already are saving firms considerable money. "For example, the automated guided vehicle is being used increasingly in many manufacturing processes," said Mr. Reynolds. "These vehicles can stop in the real world within plus or minus half an inch down to plus or minus a quarter of an inch and sometimes less, but it is really very expensive to get under that quarter of an inch. But vision can take that plus or minus half an inch and make it plus or minus 0.015 of an inch. Now, a windshield can be snapped in, a bolt tightened, or a tire loaded automatically."

According to Mr. Reynolds the new applications for vision-guided robots will be in automating new applications rather than replacing hard automation. In automotive plants, the inroads will not come in highly automated body shops or paint shops but in the poorly automated chassis area where the chassis and engines are built up, where seats are put in, final trim is applied, and where windows are inserted, among other operations. These operations require precision, and vision can provide that precision at relatively moderate prices.

Vision and tactile sensing permit robots to adapt to existing assembly conditions. However, most of the assembly robots currently being installed lack sensing abilities, making it necessary to redesign assembly lines to accommodate the robots rather than the other way around. But designing an operation to make optimum use of robots is not easy. Numerous concerns must be addressed before successful implementation can be achieved.

100 Pct Is A Requirement

One problem that must be dealt with is imperfection. "Assembly has been called a dumping ground for everyone's garbage. What this means is that when you make or buy parts and you ship them to assembly, they are not 100 pct perfect," explained GE's Mr. Estes.

"You have to have systems, then, that either inspect parts 100 pct of the time at assembly to give the robots constantly good parts; or the system has to be able to recover without human intervention when parts do not go together. The problem is that most people who want to apply robotic technology don't real-

ize how many parts humans toss aside that don't fit. If the lack of human presence is not compensated for, robots will reduce the efficiency of a line rather than enhance it."

Design For Assembly

Besides rethinking the automation process, companies must design parts for automation. Integrating a robot into assembly is not enough. Understanding how parts can best be designed for a robot to assemble is equally important.

"It is very critical that product design engineers be made aware of what is available to the manufacturing engineer today. In the past, and even today, there is often an iron curtain between manufacturing and product design," explained Mr. Rohn. "Communications must exist so that the design engineers become aware of some of the basic principles of robot assembly, like trying to assemble from the vertical, attempting to use permanent fasteners instead of screws, and minimizing the amount of parts to be assembled."

Until robots are smart enough and flexible enough to handle situations like un-oriented parts, successful robot implementation will require ingenuity on the part of designers, manufacturing engineers, and purchasing. For example, parts should be designed and manufactured or supplied in an oriented manner to eliminate orienting costs.

The greatest efforts and costs in robotic assembly are not associated with the robot or robot programming, but in feeding parts to the robot. With the exception of some standardized parts-feeding in the electronic industry, parts delivery technology has lagged behind robot development. Inflexible feeding can greatly curtail the flexibility of a robot, while significantly increasing assembly costs.

"No question about it, part orientation is a major problem," conceded Mr. Estes. "We have done some work with the University of Rhode Island and have developed what I call programmable part orientation. The system looks at similar parts all thrown together, coming down a conveyer. Vision tells the robot where the part is and which direction it is lying. The robot arm then comes down in a search mode and picks up the part.

"But, if you don't need that sophistication, you surely don't want to pay for it. Simplicity is the name of the game. It is frustrating to have manufacturing people tell me, 'I need vision or lasers,' but it is the same people who have not implemented anything."

"Delivery systems to the robots has been neglected," said Mr. Rohn of VSI. "And there have been many occasions where not only assembly robots but robots in general have gotten a bad name because people have been sold and the robot installed without support backup."

People, Automation Needed

Robots are not the only answer to flexible batch automation. Automation for most companies will be, for some time to come, a combination of hard automation, reprogrammable automation and manual labor. A number of tasks still exist which cannot yet be profitably automated.

"I think the ideal is still people and robots," said Mr. Estes. "I often tell people that if they need a device that has touch and vision and is very fast, the best thing they can buy is a human. There are tasks that are very easy for humans and are challenging as well, and those you can leave to people. Where the human is acting like a robot, there is where you want to put a robot."

If possible, firms should take an overall view of their assembly needs and then implement equipment in a modular fashion so that all the pieces will someday fit together. In reality, however, assembly equipment is usually purchased to fill an immediate need with little thought to the long term. But for whatever reason, firms should stop procrastinating and do something, comment several industry experts.

Using a robot can give a company numerous productivity advantages. The major advantage is speed, another is flexibility. "If you are going to put robots in, you want some flexibility. You want to be able to change the part and handle parts differently. In some cases, you would like to be able to try the part and if it doesn't fit the assembly, recover without human intervention: a capability that you can get in robots today," said Mr. Estes.

"I think that flexibility and speed are the strengths of assembly robots. If these are not needed, I won't even bother purchasing a robot. People get all hung up on accuracy and they want a robot to be as accurate as a machine tool. But if they ever found a robot as accurate as they wanted it, they would probably not be able to afford it anyway. There are ways to design to get around that accuracy requirement."

"The use of robots is going to blossom in assembly," said William J. Finch, president, Finch Robotics, Montgomeryville, Pa., a robot consulting firm. "Assembly is the major growth area in robots today. Manufacturers, systems houses and users are on a learning curve, gradually getting familiar with robots, getting the bugs out of operations. But companies are beginning to move rapidly up that curve."

While there is no sign of that growth abating over the next five years, robots will no longer be concentrated almost exclusively in the automotive and electronics industries. Reportedly, 40 pct of all robots are in industries that are automobile related, but the prediction is that by 1990 it will be 14 pct.

Robots will continue to grow in sophistication and speed. "There is no inherent reason why sophisticated robots with vision have to be slow," observed Mr. Reynolds of Automatix. "Vision itself is not very slow. The ability to take a picture, process the data and generate the result is very fast. However, it is the integration of vision into the proper control strategy of the robot, the transporter, and the end effector that makes for a very clumsy and sometimes slow system." On the horizon are integrated control systems expressly designed for adaptive robot control that will greatly speed up robot operations. □

PRICE & PRODUCTION DATA

(Effective May 28,1985)

Steel production by districts, thousands of tons (000 omitted)

	Last Week	Two Weeks Ago	Month Ago	Year Ago
Northeast Coast	172	175	192	258
Pittsburgh	236	227	227	323
Youngstown	102	102	111	108
Lake Erie	158	153	170	147
Detroit	152	158	147	175
Chicago	482	489	496	576
Cincinnati	94	89	100	104
St. Louis	66	61	64	92
Southern	253	249	228	230
Western	98	97	88	94
U.S. Production	1,813	1,800	1,823	2,118

Source: American Iron & Steel Institute

Lake Superior Ore Prices

51.50% Fe Natural delivered lower Lake ports. Rail transportation, handling and unloading may be charged to the account of the buyer. Coarse ore 80¢ premium.

Pellets (per iron unit natural ..... gross-ton 80.50-86.9*
Mesabi, regular-unscreened ..... gross-ton $32.53
Mesabi, non-bessemer ..... gross-ton $30.03-31.53**

*80.50¢—Pickands Mather as of 1/27/81.
86.9¢—U.S. Steel as of 3/15/82. Cleveland-Cliffs as of 2/26/82. Oglebay Norton as of 3/25/82, and Hanna Mining as of 2/26/82.
**Effective 8/1/83.

STEEL PRODUCTION, COMPOSITE PRICES

(Effective May 28,1985)

U.S. Steel Production	Last Week	Two Weeks Ago	To Date 1985	To Date 1984
Net tons, in thousands	1,813	1,800	36,390	41,333
Capability Utilization Rate	70.7	70.2	68.1	76.5

Composite Prices	This Week	Week Ago	Month Ago	Year Ago
Finished Steel Base* (¢/lb.—eff. 7/1/84)	27.582	27.582	27.582	26.939
Pig Iron** (Net ton = 2000 lbs.)	$213.00	$213.00	$213.00	$213.00
Scrap No. 1 hvy.*** (Gross ton = 2240 lbs.)	$ 70.17	$ 70.17	$ 77.50	$ 87.83
No. 2 bundles	$ 49.17	$ 49.17	$ 55.17	$ 59.50

Scrap Comparison (Gross Ton)

No. 1 steel, Pittsburgh	$ 72.50	$ 72.50	$ 79.50	$ 97.50
No. 1 steel, Philadelphia	69.50	69.50	73.50	80.50
No. 1 steel, Chicago	68.50	68.50	79.50	85.50
No. 1 bundles, Detroit	64.50	64.50	76.50	87.50
Low Phos., Youngstown	57.50	57.50	58.50	95.50
No. 1 mach'y cast., Pgh	71.50	71.50	71.50	79.50
No. 1 mach'y cast., Phila	91.50	91.50	93.50	100.50
No. 1 mach'y cast., Chi	108.50	108.50	111.50	117.50

*Finished Steel Composite. Weighted index of steel bars, shapes, plates, wire, rails, black pipe, hot and cold rolled sheets and strips.
**Pig Iron Composite. Based on average prices for basic and foundry pig iron at representative producing points within the U.S.
***Steel Scrap Composite. Average of No. 1 hvy. melting steel scrap and No. 2 bundles delivered to consumers at Pittsburgh, Philadelphia and Chicago.

NONFERROUS PRICES

(Effective May 28,1985) Prices obtained in trade based on representative tonnages per gross ton delivered to consumer unless otherwise stated.

Primary Metal Prices

(cents per lb.)	current price	last price	date of change
Aluminum (LME)	50.16	50.65	5/28/85
Copper (C)	68.00-70.00	69.00-71.00	5/28/85
Lead	20.00-21.00	21.00	4/11/85
Magnesium Ingot	148.00	143.00	5/25/84
Nickel (LME)	255.81	255.17	5/28/85
Titanium: Sponge	555.00-585.00	555.00	4/29/82
Zinc	46.00-47.00	45.00-47.00	5/1/85

ALUMINUM: Avg. for last week & previous week. COPPER (C) = cathode. LEAD: common grade. MAGNESIUM: 99.8% pig, delivered. NICKEL: Avg. for last week & previous week. ZINC: high grade.

Antimony, American Laredo, Texas	$2.00
Beryllium-aluminum 5% Be, per lb. contained Be	$230.00
Beryllium-copper, per lb. cont. Be	$144.00
Beryllium 97% powder 200-	$178.00
Cadmium, ton lots	$1.25-1.55
Calcium, ton lots, crown	$3.76
Chromium, 99.8%	$3.75
Cobalt, 99%, cathode	$12.50
Gold per troy oz.	$311.25
Indium, dollars per troy oz.	$2.50
Iridium, dollars per troy oz.	$475.00
Magnesium sticks, 10,000 lbs.	$2.02
Mercury, per 76-lb. f.o.b. N.Y.	$290.00-295.00
Molybdenum, lb. tech. moly oxides, 20 lb. MO can	$6.85
Nickel electro (PDCR)	$3.29
Palladium, per troy oz.	$107.00
Platinum, per troy oz.	$271.00
Rhodium, per troy oz.	$925.00
Silver ingots, per troy oz.	$6.02
Vanadium	$6.00
Zirconium sponge	$12.00-17.00

(Per lb. unless otherwise noted)

Straits Tin Price

(U.S. cents per lb. EX-SMELTER, based on daily market in Penang in Malaysian dollars per kilo.)

May 20—541.29
May 21—539.25
May 22—540.04
May 23—537.86
May 24—540.03

Scrap Prices
Brass Mill Scrap

(Cents per lb; over 20,000 lbs. add 1¢ per lb)

	Solids	Turnings
Copper	63	47
Yellow brass	56¾	49¾
Red brass	59½	50¼
Comm. bronze	60¾	50½
Mang. bronze	50	49
Free cutting rod ends	49	50

Custom Smelters Scrap

(Cents per lb., carload lots, del. refinery)

No. 1 copper wire	58
No. 2 copper wire	50
Light copper	41

Ingot Makers Scrap

(Cents per lb., carload lots, del. refinery)

No. 1 copper wire	54
No. 2 copper wire	46
Light copper	37
No. 1 composition	49
No. 1 comp. turnings	47
Hvy. yellow brass solids	34
Hvy. yellow brass turnings	31
Radiators	39

Aluminum

New mixed clips	32	— 33
Old sheet	29	— 31
Old cast	29	— 31
Clean dry borings	30	— 31

Dealers' Scrap

(Dealers' buying price f.o.b. New York in cents per pound)

Aluminum

Segregated clippings	27	— 29
Mixed I.C. clips	25	— 26
Old sheets and cast	21	— 23
Borings and turnings	18	— 20
Duraluminum clippings	24	— 25

Copper and Brass

No. 1 copper wire	45	— 46
No. 2 copper wire	37	— 38
Light copper	32	— 33
Radiators	30	— 31
No. 1 composition	39	— 40
No. 1 composition turnings	36	— 37
Cocks and faucets	30	— 32
Clean heavy yellow brass	28	— 29
Brass Pipe	28	— 29
New soft brass clippings	39	— 40

Lead

Heavy soft lead	6	— 8
Whole batteries	1	— 3
Type metal	16	— 17
Electrotype	13	— 15

Nickel

Nickel solids	120	—130
Nickel rod ends	120	—130
Nickel sheets, clips	120	—130
Nickel turnings	35	— 45

Zinc

New zinc clippings	17	— 18
Old diecast zinc	13	— 14

EFFECTIVE MAY 28, 1985

(Effective May 28,1985) Prices obtained in trade based on representative tonnages per gross ton delivered to consumer unless otherwise stated. Prices are the opinions of *Iron Age* editors and correspondents, based on contacts with dealers, brokers, generators and users in the industry on the effective date listed above.

Ferrous Scrap Prices

Pittsburgh

No. 1 hvy. melting	$ 72.00 to	$ 73.00
No. 2 hvy. melting	62.00 to	63.00
No. 1 dealer bundles	81.00 to	82.00
No. 1 factory bundles (auto)	76.00 to	77.00
No. 2 bundles	56.00 to	57.00
No. 1 busheling	79.00 to	80.00
Machinte shop turnings	7.00 to	8.00
Shoveling turnings	40.00 to	41.00
Cast iron borings	38.00 to	39.00
Low phos. punchings plate	90.00 to	91.00
Heavy turnings	64.00 to	65.00
No. 1 RR hvy. melting	78.00 to	79.00
Rails, 2 ft. and under	95.00 to	96.00
Scrap rails, random lgth	82.00 to	83.00
RR specialties	88.00 to	89.00
No. 1 machinery cast	71.00 to	72.00
Cupola cast	64.00 to	65.00
Heavy breakable cast	30.00 to	31.00
Stainless		
18-8 bundles and solids	615.00 to	625.00
18-8 turnings	515.00 to	525.00

Chicago

No. 1 hvy. melting	$ 68.00 to	$ 69.00
No. 2 hvy. melting	64.00 to	65.00
No. 1 dealer bundles	79.00 to	80.00
No. 1 factory bundles (auto)	77.00 to	78.00
No. 2 dealer bundles	49.00 to	50.00
No. 1 busheling	76.00 to	77.00
Shredder scrap	76.00 to	77.00
Machine shop turnings	35.00 to	36.00
Mixed borings and turnings	36.00 to	37.00
Shoveling turnings	37.00 to	38.00
Cast iron borings	39.00 to	40.00
Low phos. forge crop	103.00 to	104.00
Low phos. punchings plate 1/4 in. and heavier	117.00 to	118.00
Low phos. 2 ft. and under	112.00 to	113.00
No. 1 RR hvy. melting	71.00 to	72.00
Scrap rails random lgth	75.00 to	76.00
Reroller rails	96.00 to	97.00
Rails, 2 ft. and under	104.00 to	105.00
RR couplers and knuckles	90.00 to	91.00
RR car axles	107.00 to	108.00
No. 1 machinery cast	108.00 to	109.00
Cupola cast	95.00 to	96.00
Stove plate	94.00 to	95.00
Steel car wheels	84.00 to	85.00
Stainless		
18-8 bundles and solids	545.00 to	555.00
18-8 turnings	465.00 to	475.00
430 bundles and solids	130.00 to	135.00
430 turnings	100.00 to	105.00

Philadelphia

No. 1 hvy. melting	$ 68.00 to	$ 71.00
No. 2 hvy. melting	58.00 to	61.00
No. 1 dealer bundles	75.00 to	78.00
No. 2 dealer bundles	40.00 to	43.00
No. 1 busheling	75.00 to	78.00
Shredder scrap	80.00 to	83.00
Machine shop turnings	25.00 to	28.00
Mixed borings and turnings	25.50 to	28.00
Shoveling turnings	37.00 to	40.00
Low phos. 5 ft. and under	78.00 to	81.00
Low phos. 2 ft. punchings	97.00 to	100.00
Electric furnace bundles	85.00 to	88.00
RR specialties	78.00 to	81.00
Rails, 2 ft. and under	100.00 to	103.00
Cupola cast	75.00 to	78.00
Heavy breakable cast	53.00 to	56.00
No. 1 machinery cast	90.00 to	93.00

Detroit

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 52.00 to	$ 53.00
No. 2 hvy. melting	51.00 to	52.00
No. 1 dealer bundles	64.00 to	65.00
No. 2 bundles	30.00 to	31.00
No. 1 busheling	63.00 to	64.00
Drop forge flashings	42.00 to	43.00
Machine shop turnings	41.00 to	42.00
Mixed borings and turnings	18.00 to	19.00
Shoveling turnings	42.00 to	43.00
Cast iron borings	25.00 to	26.00
Heavy breakable cast	35.00 to	36.00
Mixed cupola cast	50.00 to	51.00
Automobile cast	74.00 to	75.00
Stainless		
18-8 bundles and solids	510.00 to	520.00
18-8 turnings	415.00 to	425.00
430 bundles and solids	115.00 to	125.00

Youngstown

No. 1 hvy. melting	$ 50.00 to	$ 53.00
No. 2 hvy. melting	39.00 to	42.00
No. 1 dealer bundles	57.00 to	60.00
No. 2 dealer bundles	29.00 to	32.00
Machine shop turnings	8.00 to	11.00
Shoveling turnings	13.00 to	16.00
Low phos. plate	56.00 to	59.00
Electric furnace bundles	53.00 to	56.00
Galvanized bundles	46.00 to	49.00

Cleveland

No. 1 hvy. melting	$ 50.00 to	$ 53.00
No. 2 hvy. melting	30.00 to	33.00
No. 1 dealer bundles	55.00 to	58.00
No. 1 factory bundles	56.00 to	59.00
No. 2 bundles	28.00 to	31.00
No. 1 busheling	55.00 to	58.00
Machine shop turnings	8.00 to	11.00
Mixed borings and turnings	10.00 to	13.00
Shoveling turnings	10.00 to	13.00
Cast iron borings	15.00 to	18.00
Cut structural & plates, 2 ft. and under	87.00 to	90.00
Low phos. punchings plate	87.00 to	90.00
Drop forge flashings	43.00 to	46.00
Foundry steel, 2 ft. & under	69.00 to	72.00
No. 1 RR hvy. melting	60.00 to	63.00
Rails, 2 ft. and under	86.00 to	89.00
Rails, 18 in. and under	90.00 to	93.00
Steel axle turnings	56.00 to	59.00
Railroad cast	87.00 to	90.00
No. 1 machinery cast	90.00 to	93.00
Cupola cast	55.00 to	58.00
Stove plate	53.00 to	56.00
Stainless		
18-8 bundles	375.00 to	385.00
18-8 turnings	325.00 to	335.00
430 bundles	80.00 to	85.00

Buffalo

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 51.00 to	$ 52.00
No. 2 hvy. melting	41.00 to	42.00
No. 1 busheling	62.00 to	63.00
No. 1 dealer bundles	62.00 to	63.00
No. 2 bundles	32.00 to	33.00
Machine shop turnings	17.00 to	18.00
Mixed boring and turnings	17.00 to	18.00
Shoveling turnings	26.00 to	27.00
Cast iron borings	24.00 to	25.00
Low phos. plate	81.00 to	82.00
Structural and plate, 2 ft. and under	83.00 to	84.00
Rails, 2 ft. and under	83.00 to	84.00
Scrap rails, random lgth	65.00 to	66.00
No. 1 machinery cast	76.00 to	77.00
No. 1 cupola cast	58.00 to	59.00

St. Louis

No. 1 hvy. melting	$ 53.00 to	$ 54.00
No. 2 hvy. melting	40.00 to	41.00
Foundry steel, 2 ft.	50.00 to	51.00
No. 1 dealer bundles	53.00 to	54.00
No. 2 bundles	35.00 to	36.00
Machine shop turnings	14.00 to	15.00
Shoveling turnings	20.00 to	21.00
Cast iron borings	28.00 to	29.00
No. 1 RR hvy. melting	56.00 to	57.00
Rails, random length	59.00 to	60.00
Rails, 18 in. and under	72.00 to	73.00
RR specialties	71.00 to	72.00
Cupola cast	76.00 to	77.00
Heavy breakable cast	54.00 to	55.00
Stove plate	91.00 to	92.00
Steel car wheels	79.00 to	80.00
Rerolling rails	68.00 to	69.00
Unstripped motor blocks	63.00 to	64.00

Birmingham

No. 1 hvy. melting	$ 73.00 to	$ 74.00
No. 2 hvy. melting	69.00 to	70.00
No. 1 dealer bundles	74.00 to	75.00
No. 2 bundles	48.00 to	49.00
No. 1 busheling	74.00 to	75.00
Shredder scrap	87.00 to	88.00
Machine shop turnings	27.00 to	28.00
Shoveling turnings	40.00 to	41.00
Cast iron borings	37.00 to	38.00
Electric furnace bundles	70.00 to	71.00
Elec. furnace, 3 ft. & under	70.00 to	71.00
Structural and plate, 2 ft	86.00 to	87.00
Structural and plate, 4 ft	85.00 to	86.00
No. 1 RR hvy. melting	83.00 to	84.00
Scrap rails, random lgth	77.00 to	78.00
Rails, 2 ft. and under	91.00 to	92.00
Angles and splice bars	83.00 to	84.00
No. 1 cupola cast	84.00 to	85.00
Unstripped motor blocks	75.00 to	76.00

Cincinnati

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 44.00 to	$ 45.00
No. 2 hvy. melting	43.00 to	44.00
No. 1 dealer bundles	49.00 to	50.00
No. 2 bundles	24.00 to	25.00
Machine shop turnings	4.00 to	5.00
Shoveling turnings	6.00 to	7.00
Cast iron borings	13.00 to	14.00
Low phos. 18 in. and under	76.00 to	77.00
Rails, random length	54.00 to	55.00
Rails, 2 ft. and under	69.00 to	70.00
No. 1 cupola cast	55.00 to	56.00
Heavy breakable cast	22.00 to	23.00
Drop broken cast	70.00 to	71.00

New York

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 44.00 to	$ 45.00
No. 2 hvy. melting	35.00 to	36.00
No. 2 dealer bundles	20.00 to	24.00
Mixed borings and turnings	10.00 to	11.00
Machine shop turnings	4.00 to	6.00
Shoveling turnings	10.00 to	12.00
Clean cast, chem. borings	35.00 to	36.00
No. 1 machinery cast	79.00 to	80.00
Mixed yard cast	50.00 to	51.00
Heavy breakable cast	10.00 to	12.00
Stainless		
18-8 prepared solids	520.00 to	540.00
18-8 turnings	420.00 to	440.00
430 prepared solids	90.00 to	110.00
410 solids	80.00 to	90.00

Boston

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 49.00 to	$ 51.00
No. 2 hvy. melting	39.00 to	41.00
No. 1 dealer bundles	51.00 to	53.00
No. 2 bundles	32.00 to	34.00
No. 1 busheling	57.00 to	59.00
Shredder scrap	59.00 to	61.00
Machine shop turnings	10.00 to	12.00
Shoveling turnings	18.00 to	20.00
No. 1 machinery cast	75.00 to	80.00
Mixed cupola cast	42.00 to	44.00
Heavy breakable cast	8.00 to	10.00

San Francisco

No. 1 hvy. melting	$ 40.00 to	$ 42.00
No. 2 hvy. melting	34.00 to	36.00
No. 1 dealer bundles	31.00 to	33.00
No. 2 dealer bundles	18.00 to	20.00
Machine shop turnings	8.00 to	9.00
Cast iron borings	8.00 to	9.00
No. 1 cupola cast	81.00 to	83.00

Los Angeles

No. 1 hvy. melting	$ 43.00 to	$ 45.00
No. 2 hvy. melting	36.00 to	38.00
No. 1 dealer bundles	34.00 to	36.00
No. 2 dealer bundles	18.00 to	20.00
Machine shop turnings	13.00 to	14.00
Shoveling turnings	10.00 to	11.00
Cast iron borings	8.00 to	9.00
Elec. furnace, 1 ft. and under (foundry)	74.00 to	76.00
No. 1 cupola cast	75.00 to	77.00

Seattle

No. 1 hvy. melting	62.00 to	64.00
No. 2 hvy. melting	53.00 to	55.00
No. 2 bundles	36.00 to	38.00
No. 1 cupola cast	92.00 to	93.00
Mixed yard cast	82.00 to	84.00

Hamilton, Ont.

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 76.00
No. 2 hvy. melting, cut 2 ft. and under	68.00
No. 1 dealer bundles	74.00
No. 2 bundles	52.00
Mixed steel scrap	50.00
Bush. new fact. prep'd	76.00
Bush. new fact. unprp'd	65.00
Machine shop turnings	33.00
Short steel turnings	33.00
Mixed borings and turnings	20.00
Cast scrap	90.00

Houston

Brokers buying prices per gross ton on cars:

No. 1 hvy. melting	$ 71.00 to	$ 72.00
No. 2 hvy. melting	57.00 to	58.00
No. 2 bundles	43.00 to	44.00
Machine shop turnings	15.00 to	16.00
Crushed turnings	32.00 to	33.00
Shredder scrap	79.00 to	80.00
Cut structural plate, 2 ft. and under	99.00 to	100.00
Cut structural plate, 5 ft. and under	83.00 to	84.00
Unstripped motor blocks	60.00 to	61.00
Cupola cast	84.00 to	85.00

RANGE OF PRICE CHANGES CONTINUES TO NARROW

Producer finished goods prices in April continued to edge up only grudgingly.

The U.S. Department of Labor's index rose 0.3 pct on a seasonally adjusted annual basis. That followed a 0.2 pct rise in March.

These prices rose by only 0.7 pct over the first 4 months of 1985.

Energy prices moved up a strong 5.8 pct in April. However, prices of consumer foods declined by 1.0 pct. The April food price drop was the deepest decline in any month over the past 12 months.

Prices of capital equipment were unchanged in April. Price decreases for motor vehicles, transformers and machine tools offset increases for aircraft, office machines and commercial furniture.

The table here gives a picture of remarkable price stability in metalworking product lines. Month-to-month price declines were scored by 5 of the 22 product lines listed. In 7 lines, no price changes occurred. Prices were up by only 0.1 pct in six categories.

In sum, 18 of the 22 product lines showed actual price declines, or remained almost static in April.

The two lines showing the strongest price push in April were mechanical power transmission equipment (up 0.7 pct), and railroad equipment (up 0.4 pct). Those showing the most notable price weakness were construction machinery and equipment and heating equipment, both down by 0.2 pct.

These strongest of the up and down movements in April do not point to any trend. The product lines have had similar ups and downs over a long span of time.

The combination of slowed business and world-level competition continues as the leading cause of price stability in metalworking goods lines.

Latest Month Covered: April 1985

Products	Index Reading For Month (1967 = 100)	Pct Change From Previous Month	Pct Change From Year-Ago Month
Metal Cutting Machine Tools	396.0	0	+ 3.2
Metal Forming Machine Tools	432.6	— 0.1	+ 2.8
Agricultural Machinery & Equip.	339.0	0	+ 1.0
Construction Machinery & Equip.	361.2	— 0.2	+ 1.0
Industrial Process Furnace & Ovens	384.1	+ 0.1	+ 2.9
Industrial Material Handling Equip.	293.9	0	+ 2.2
Pumps, Compressors & Allied Equip.	355.4	— 0.1	+ 1.5
Fluid Power Equip. (Dec. 1970 = 100)	263.8	+ 0.3	+ 2.6
Mechanical Power Transmission Equip.	337.6	+ 0.7	+ 4.5
Automobiles	226.9	0	+ 2.2
Motor Trucks—Light	296.1	0	+ 4.8
Motor Trucks—Heavy	332.3	0	— 0.6
Railroad Equipment	364.0	+ 0.4	+ 2.7
Fabricated Metal Structural Products	314.3	0	+ 1.6
Electric Motors	350.6	+ 0.1	+ 3.3
Valves & Fittings (Dec. 1982 = 100)	104.4	+ 0.1	+ 2.5
Ball & Roller Bearings	347.1	— 0.1	+ 2.7
Cutting Tools & Accessories	285.9	+ 0.1	+ 2.7
Heating Equipment	257.8	— 0.2	+ 3.0
Plumbing Fixtures & Brass Fittings	311.3	+ 1.1	+ 3.3
Metal Containers	358.0	+ 0.1	+ 3.7
Miscellaneous Metal Products	302.1	+ 0.1	+ 3.1

Data based on U.S. Labor Dept.'s Producer Price Index